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COMPRESSOR

The compressor in an automotive A/C system serves two important functions:

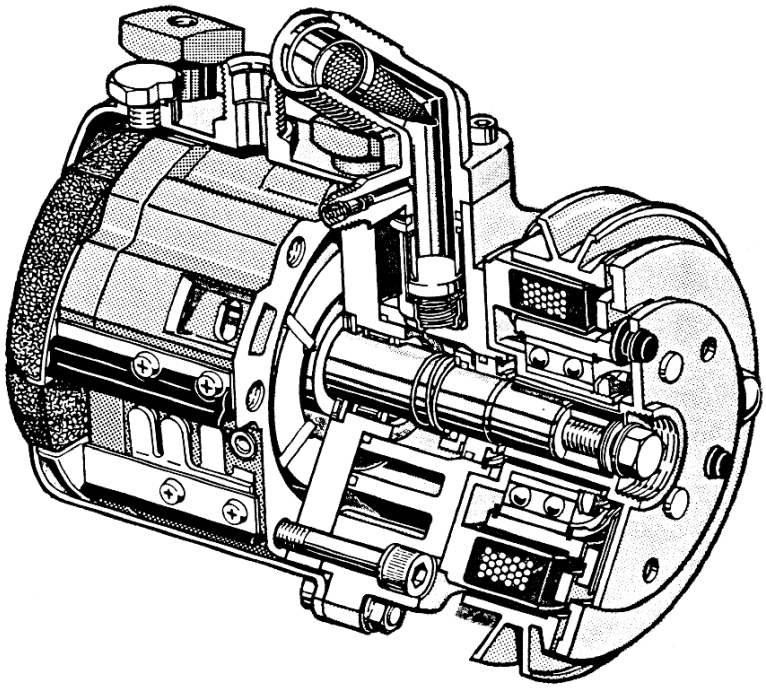
- It creates a low-pressure zone at the compressor inlet, to draw refrigerant vapor from the evaporator.

- It compresses the low-pressure refrigerant vapor into a high-pressure vapor and sends it toward the condenser.

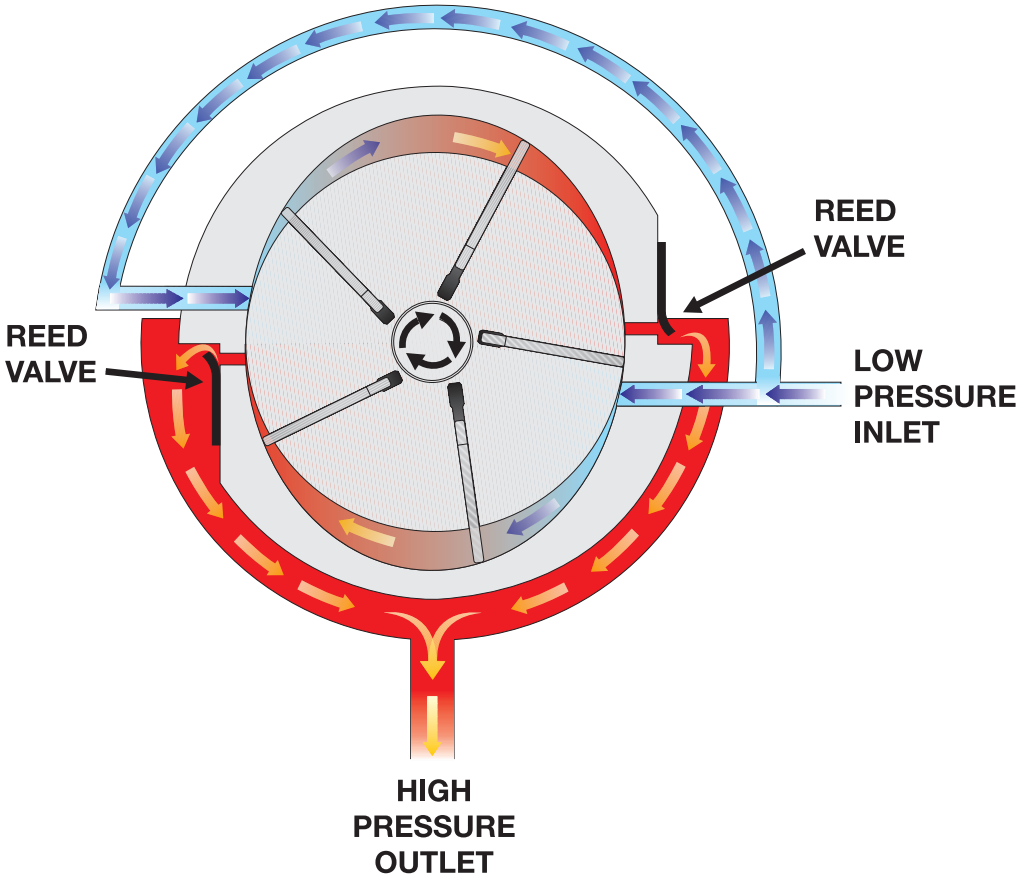
BMW A/C systems use various types of compressors. These include:

- Seiko-Seiki rotary vane compressor

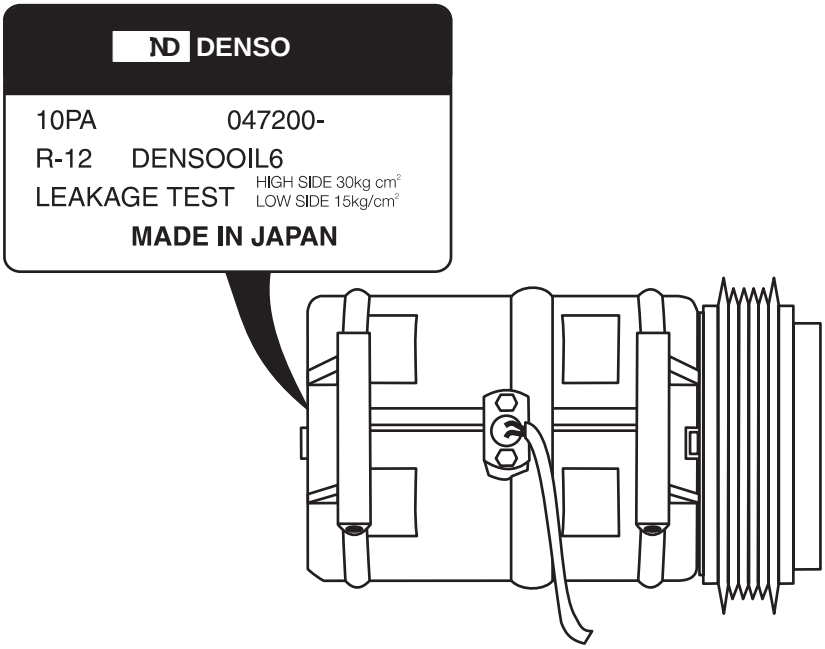
- Nippondenso swash-plate design



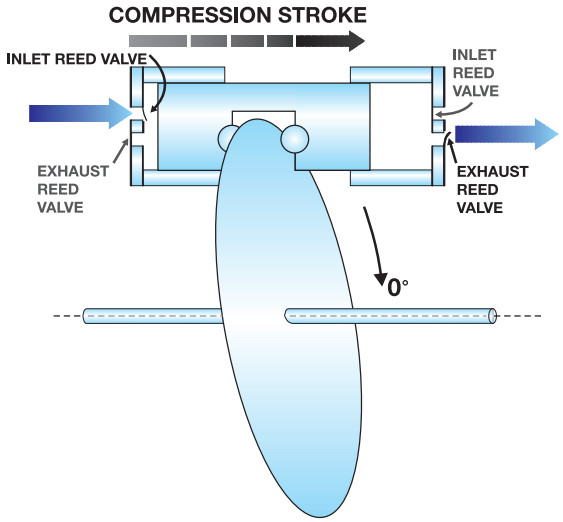
The Seiko-Seiki type is a five-vane rotary compressor. It consists of a shaft with vanes, that maintain contact with the inner wall of a cavity. The cavity is shaped like an ellipse. As the shaft rotates, oil pressure and centrifugal force push out on the vanes, so that their outer edges stay in contact with the cavity. This creates spaces where the volume is expanded and contracted, to draw refrigerant vapor in, compress it, and force it out.

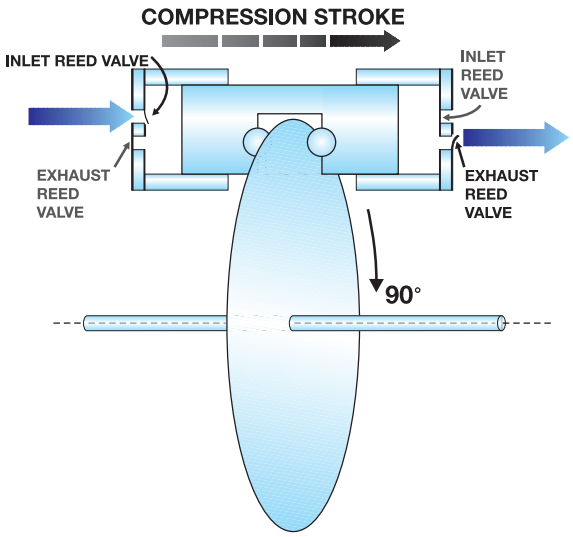


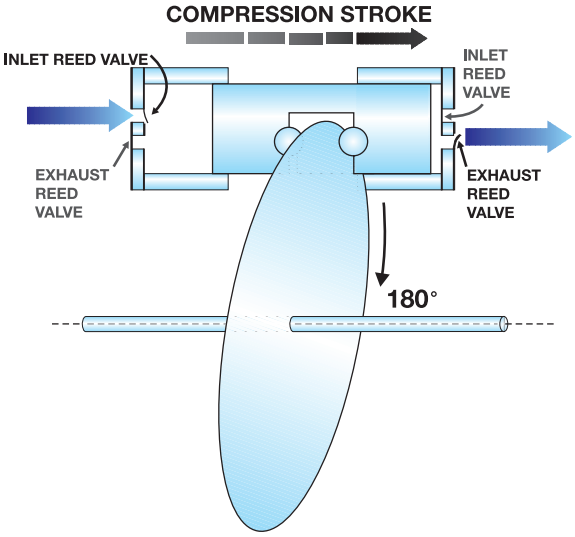
When the space between the shaft and the cavity is large, the pressure is low. Refrigerant vapor is drawn into the space. When the vane passes the inlet port, the space is sealed off; no more refrigerant vapor can be drawn in. As the vane sweeps through 180°, the space shrinks, compressing the refrigerant. The refrigerant is then forced out through reed valves, to the discharge ports.



The Nippondenso compressor is a five-cylinder swash-plate compressor. The swash plate is set on an angle, and it rotates with the shaft. As it goes through one complete revolution, it drives pistons from one end of their travel to the other, and back again. As it drives a piston forward in its cylinder, the piston compresses the refrigerant in the cylinder. The compressed refrigerant is then discharged. As the swash plate pulls a piston back, the piston draws refrigerant into the cylinder.







COMPRESSOR REGULATION - COOLING

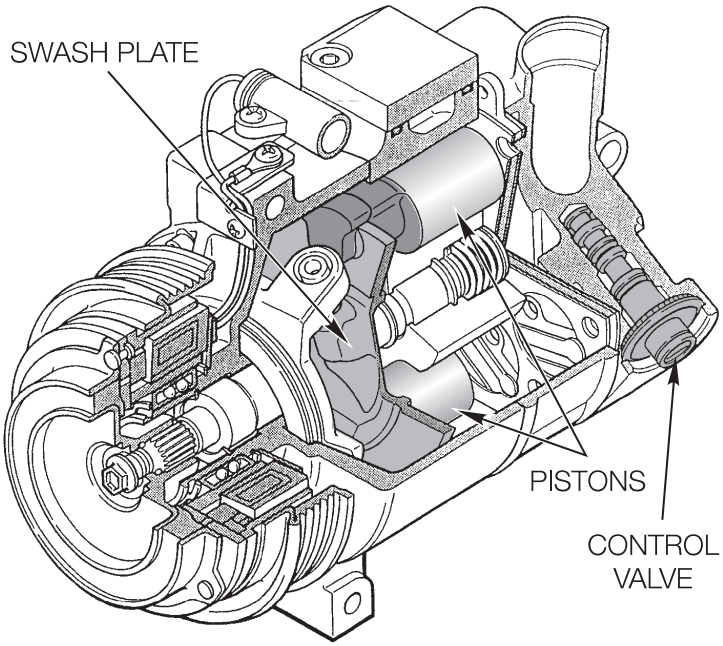
The E39, 9/97 E38 750iL, E46 - IHKA uses a new variable displacement A/C compressor.

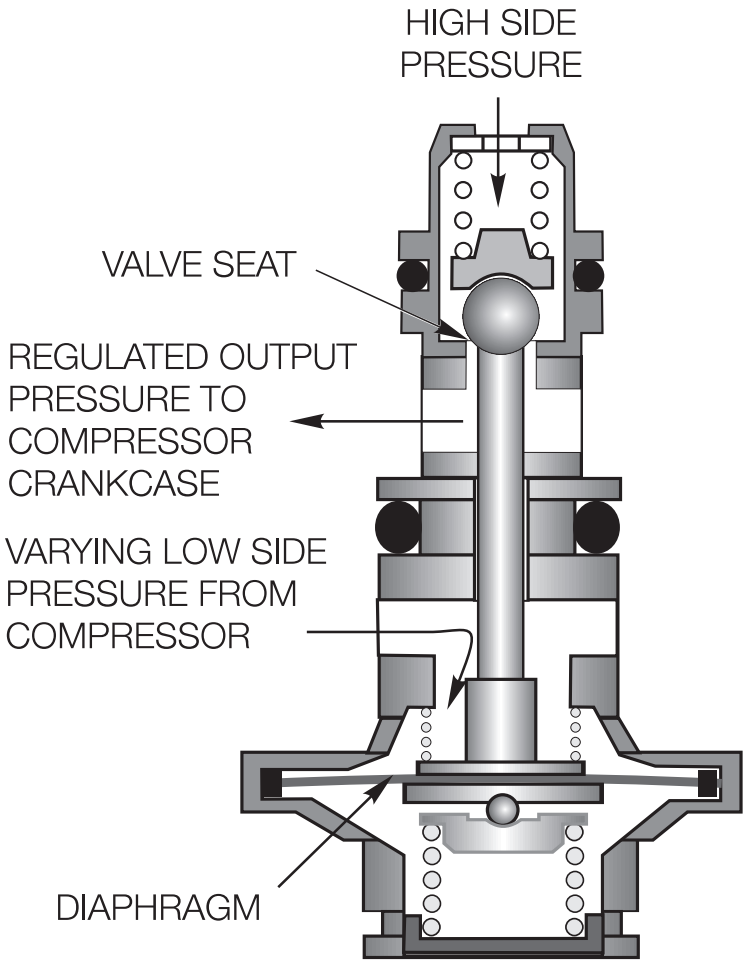
The swash plate of the compressor is hinged so that it can vary the piston travel based on the output requirements of the system. The swash plate position is controlled by the control valve located in the compressor.

The control valve regulation is based on the low and high side pressures of the system. A “high” low side pressure (high load) will cause the control valve to close and block discharge pressure from entering into the crankcase of the compressor.

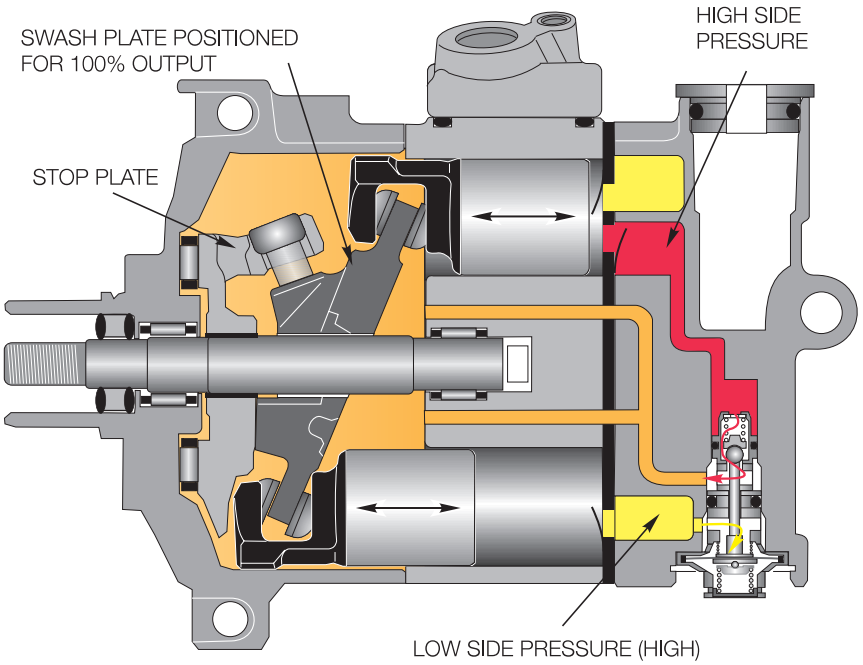
When the low side pressure decreases, the control valve opens. The swash plate moves to a position of minimum travel and consequently reduces the compressor output.

The compressor output varies continually based on the constant change in the contributing pressures.



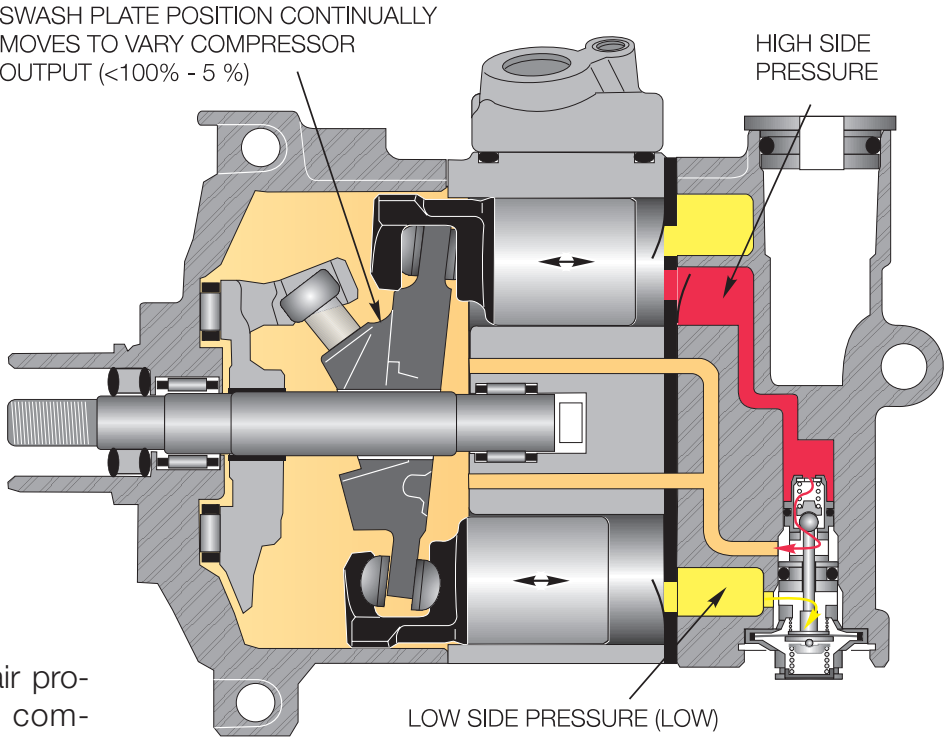


At low engine RPMs and/or high temperature loads, the piston travel (displacement) of the compressor pistons are at the maximum point. This allows the compressor to provide maximum cooling efficiency at idle speeds and when high output is required (heavy demand for cooling).



At higher engine RPMs and when the load on the system is low, the swash plate moves so that the piston travel is shortened.

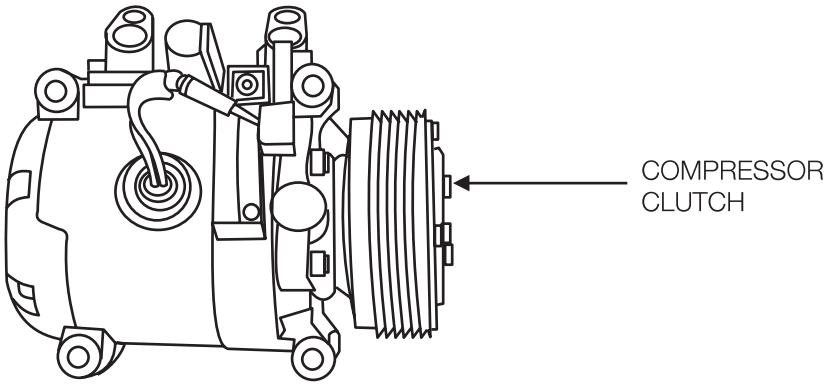
This reduces the constant high load output of the compressor any time the A/C system is on. It also reduces the cycling of the compressor due to the low temperature of the evaporator (evaporator temperature sensor causing the system to cycle at 3°C). An overall effect of this is improved fuel economy.



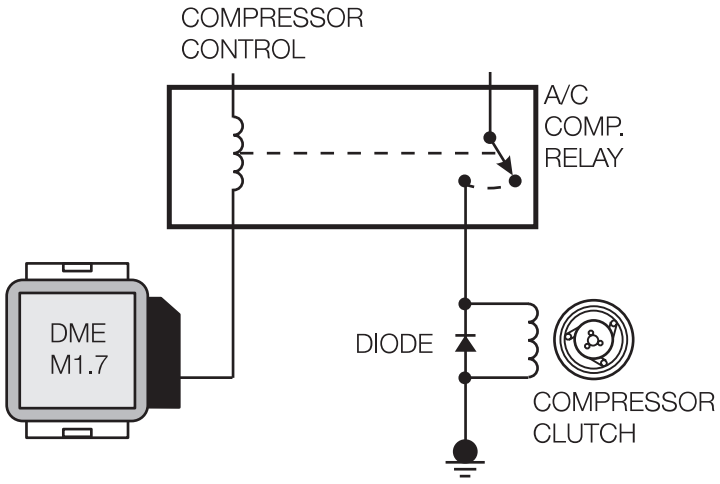
NOTE: Refer to repair procedures for proper compressor replacement and correcting oil level.

COMPRESSOR CLUTCH

The compressor pulley is driven by a belt from the crankshaft; a compressor clutch is used to engage/disengage the pulley and driveshaft. The clutch is electromagnetic. When power is provided to the clutch, the clutch engages and rotates the compressor drive shaft. When the power is cut off, the clutch disengages and the compressor pulley free-wheels. On BMW A/C systems, the compressor is cycled on and off, according to evaporator temperature; it is also cycled off at full-throttle, standing start acceleration conditions.



A diode is used to prevent induced current and voltage from damaging the control module/relays when the clutch solenoid is disengaged. The diode allows the voltage spike created when the clutch solenoid is disengaged, to flow in a loop back through the solenoid coil, until the energy is dissipated. Different vehicles use different control modules to control the compressor clutch.



The compressor clutch is unit replaceable.

COMPRESSOR SERVICE

- When troubleshooting a noisy compressor complaint, make sure the noise is present only when the clutch is engaged.

- If it is present when the clutch is not engaged, remove the compressor drive belt and check again.

- If the noise continues, it is not related to the compressor.

- If removing the drive belt reduces or eliminates the noise, check the torque of the compressor and bracket mounting bolts.

- Check the belt tension and condition, and tensioner pullies which can produce rattling noises that would sound like a defective compressor.

- A loose/slipping belt can cause noise.

- A belt that is too tight can damage the clutch bearings.

- If the compressor is noisy with the compressor clutch engaged, make sure the system is charged with the correct amount of refrigerant.

- An over-charged system can cause compressor noise.

- If the A/C system is overcharged with refrigerant, the liquid entering the compressor can damage it.

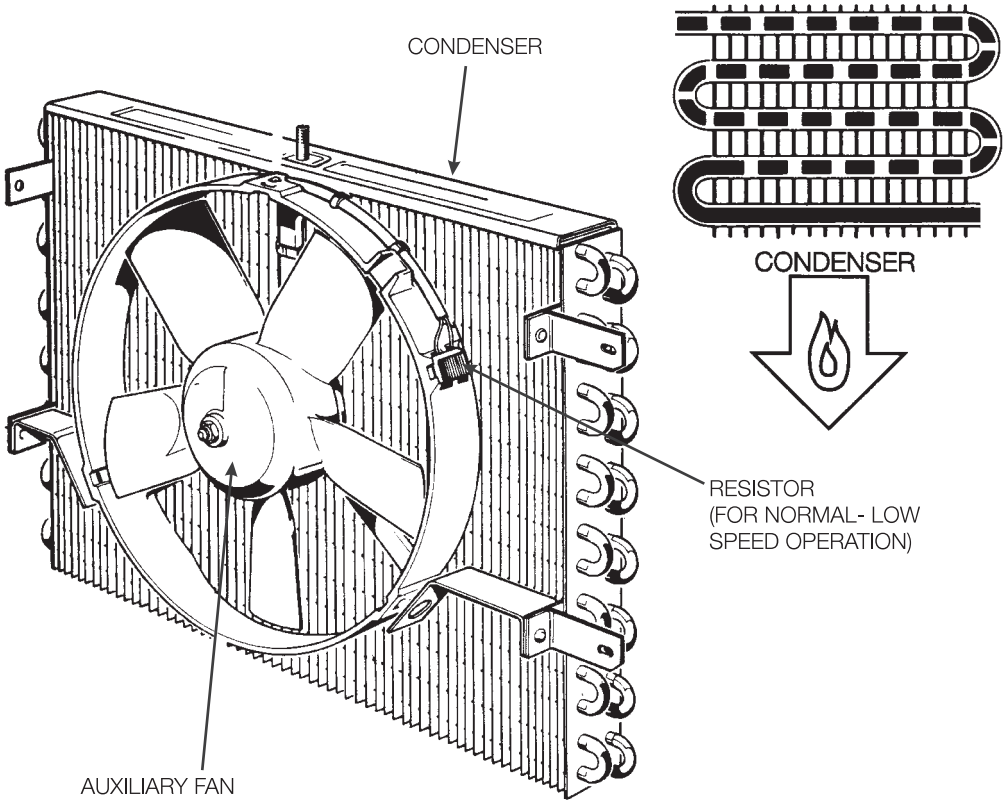
- When troubleshooting a noisy compressor complaint, recover the refrigerant and recharge the system with the correct amount.

- A failed compressor must be returned with the inlet and outlet ports sealed using the plastic caps from the replacement compressor. Otherwise the “failed” compressor will be damaged by moisture, and it will be impossible for Warranty to analyze it.

- For details on compressor replacement, see the TIS, Group 64

CONDENSER

The compressor pumps the refrigerant to the top of the condenser. Almost all of it is a high-pressure vapor, at this point. Because of its high pressure, the temperature at which it can condense is much higher. The high pressure allows the refrigerant to change from a vapor to a liquid, when ambient air, passing over the condenser, carries some of its heat away. Most of the refrigerant is a high-pressure liquid by the time it reaches the bottom of the condenser. The condenser (like the radiator and the heater core) is also a “heat exchanger.”



The condenser on BMW A/C systems is equipped with an auxiliary fan that provides additional air flow through the radiator and condenser, when needed.

Auxiliary fan control systems vary from vehicle to vehicle. The following is a typical “basic” example of how an auxiliary fan is controlled.

The auxiliary fan is controlled by two normally open relays, a normal-speed relay, which runs the fan at the “normal” speed; and a high-speed relay, which runs the fan at the “high” speed.

The A/C control module grounds the normal-speed relay whenever the A/C system is turned on. This causes the fan to run at the normal speed.

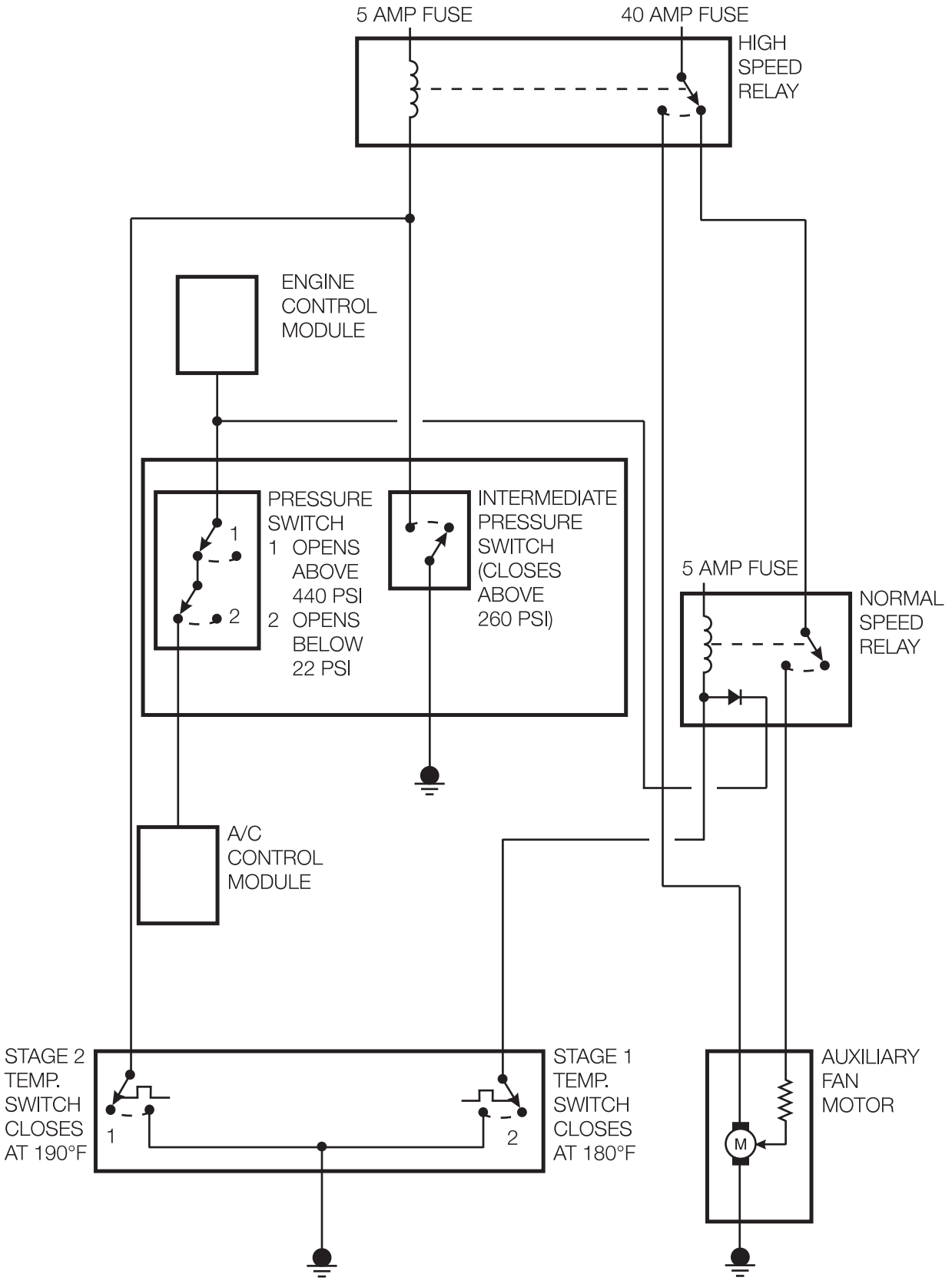
The relays are also energized by a (normally open) double temperature switch, which senses coolant temperature in the radiator. When coolant temperature rises above 180° F (82° C), the normal-speed half of the switch closes, powering the normal-speed relay, and the auxiliary fan runs at the normal speed, whether or not the snowflake button is depressed.

When the temperature rises above 190° F (88° C), the high-speed half of the switch closes, powering the high-speed relay, and the auxiliary fan runs at high speed.

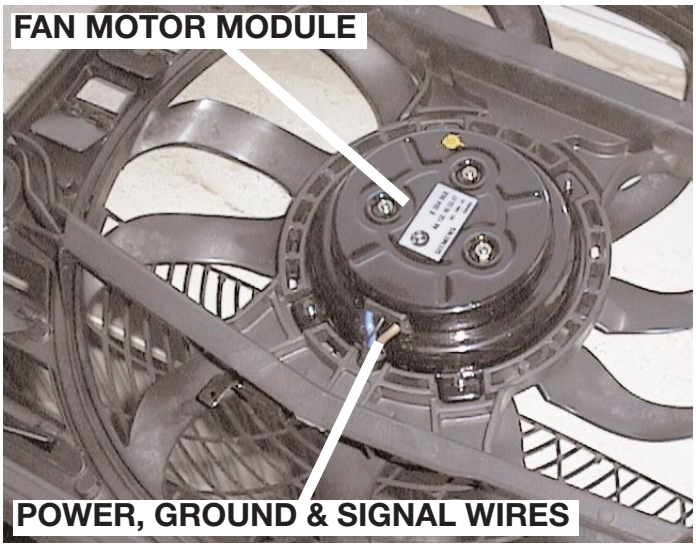
There is also an intermediate pressure switch fitted to the receiver/dryer. This switch, which is normally open, closes when refrigerant pressure exceeds 260 psi. This energizes the high-speed relay and runs the auxiliary fan at high speed.

The details of auxiliary fan controls on other BMW vehicles are different. Refer to the Electrical Troubleshooting Manuals (ETMs) for vehicle specific information.

AUXILIARY FAN - TYPICAL WIRING DIAGRAM



AUXILIARY FAN CONTROL - E46 & E38, E39 (as equipped)



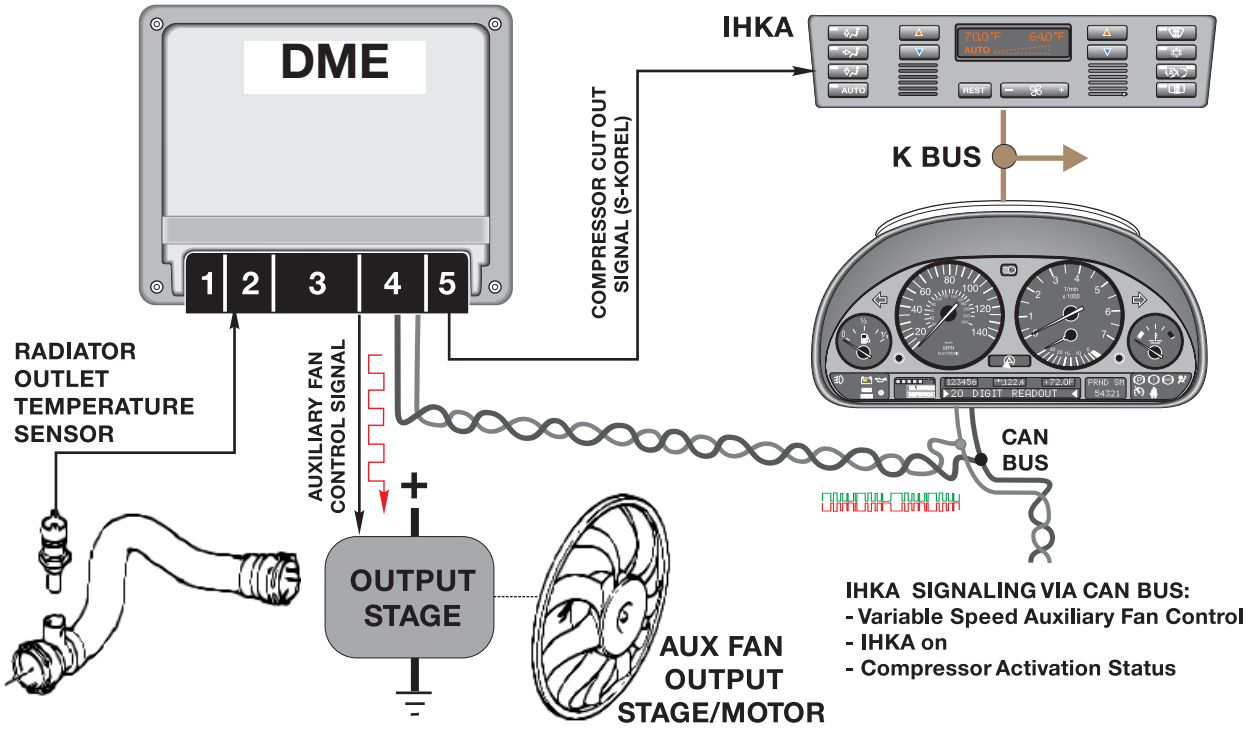
The Auxiliary Fan motor incorporates an output final stage that activates the fan motor at variable speeds.

The auxiliary fan is controlled by ECM. The motor output stage receives power and ground and activates the motor based on a PWM signal (10 - 100Hz) received from the ME 7.2.

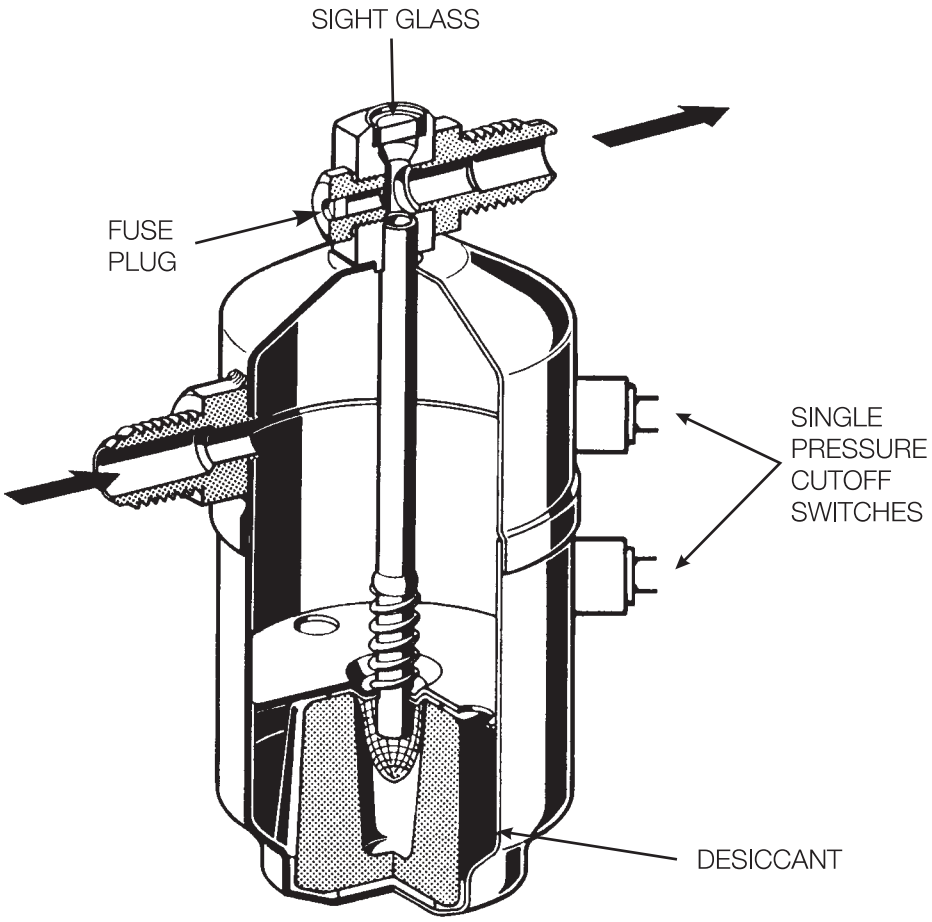
The fan is activated based on the following factors:

- Radiator outlet temperature sensor input exceeds a preset temperature.
- IHKA signalling via the K and CAN bus based on calculated refrigerant pressures.
- Vehicle speed.
- Battery voltage level

When the over-temperature light in the instrument cluster is on (120ºC) the fan is run in the overrun function. This signal is provided to the DME via the CAN bus. When this occurs the fan is run at a frequency of 10Hz.



R-12 RECEIVER/DRYER



R-12 Receiver/Dryer

From the condenser, liquid refrigerant under high pressure flows to the receiver/dryer. The receiver/dryer consists of a cylindrical tank to hold the refrigerant and a solid dryer (comprised of a desiccant such as silica gel, for an R-12 system, or zeolite, for an R-134a system; molecular sieves; and aluminum oxides). The receiver/dryer is designed to separate refrigerant vapor from liquid, so that only liquid is fed to the expansion valve.

The liquid refrigerant enters the tank on the side and flows downward through the solid dryer. Contamination is filtered out by the screen. The dryer absorbs moisture, dirt and acid. However, the dryer element can only absorb a small amount of moisture (6-10 grams for an R-12 system; and 10-16 grams for an R-134a system).Early receiver/dryers have two pressure switches, a high-pressure cutoff switch and a low-pressure cutoff switch. Later receiver/dryers have a combination high/low cutoff switch. These switches interrupt power to the compressor clutch when pressure in the refrigerant circuit is too low or too high.

R-134a receiver/dryers are now used to replace R-12 receiver/dryers.

Repair Procedure:

Replace the high pressure switch along with the receiver/dryer if the fusible plug is found open.

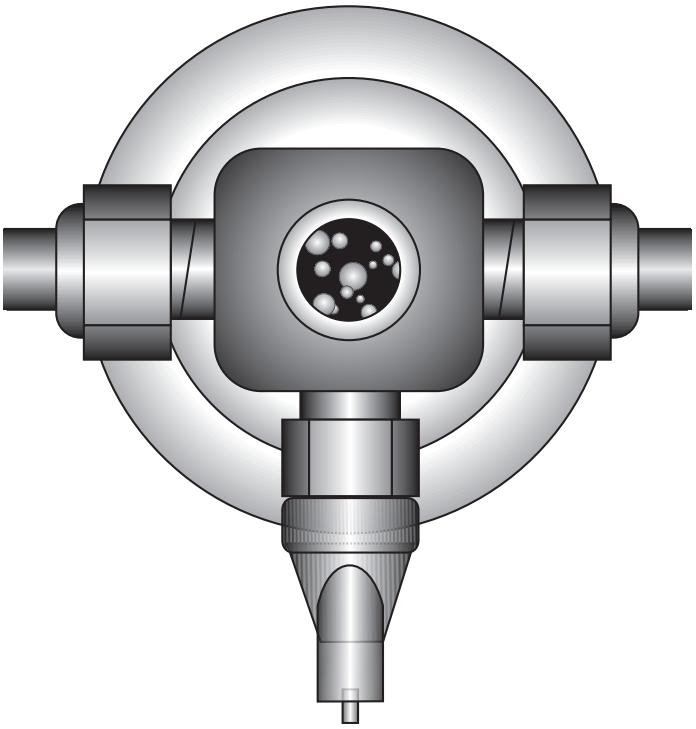
The following items should also be checked for proper function as the system should not normally operate at these high pressures:

- Auxiliary Fan
- 108ºC Coolant Temperature Switch (M Series Cars Only)
- 150ºC Compressor Temperature Switch (models so equipped)
- Operating pressures - blockage or restriction in system

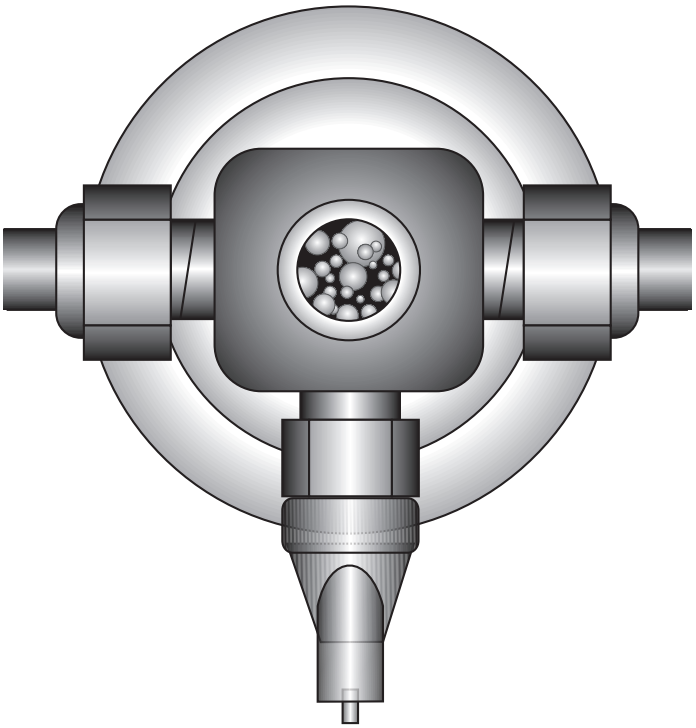
PROPER READING OF THE SIGHT GLASS

On R-12 A/C systems, look at the sight glass of the receiver/dryer. This will provide preliminary information on the condition of the refrigerant. With an R-12 system, there will be differences between the cold and hot weather appearance of the sight glass. Generally speaking, bubbles tend to appear in hot weather and are slow to appear in cold weather.

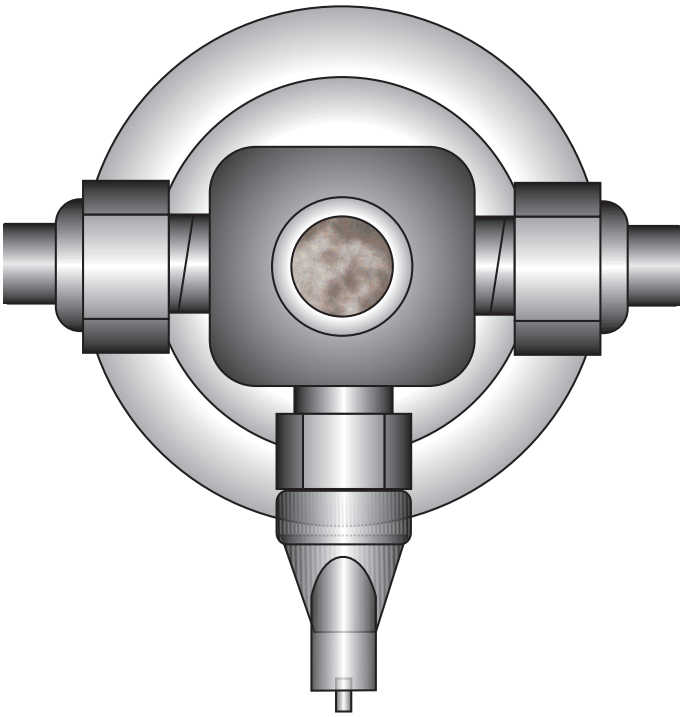
- A few bubbles show up 2 - 3 seconds after the compressor cycles on.
- High-pressure side is hot and low-pressure side is cold.
- Refrigerant is sufficient.



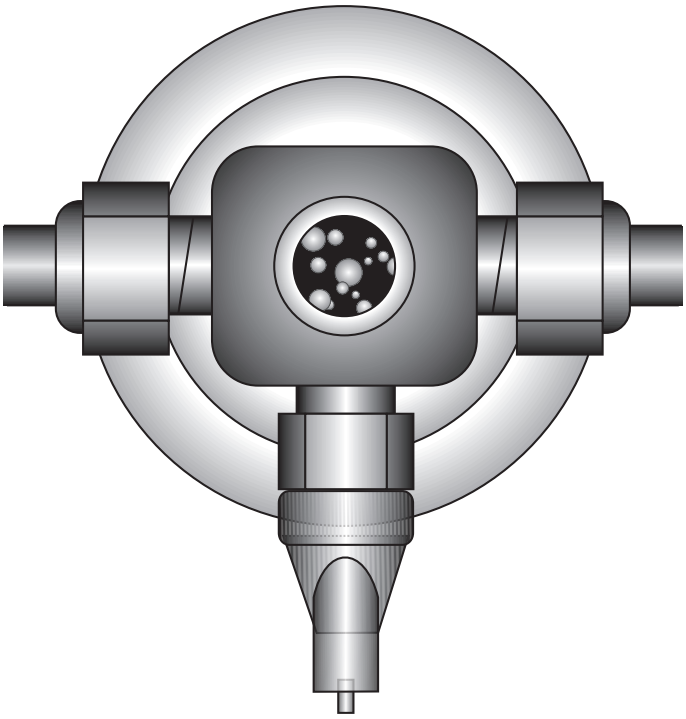
- Bubbles flow continuously; oil streaks.
- Almost no difference in temperature between low- and high-pressure sides.
- Likely to be very little refrigerant.



- “Mist”-like flow, with bubbles totally absent.
- No difference in temperature between the low- and high-pressure sides.
- Probably means no refrigerant.

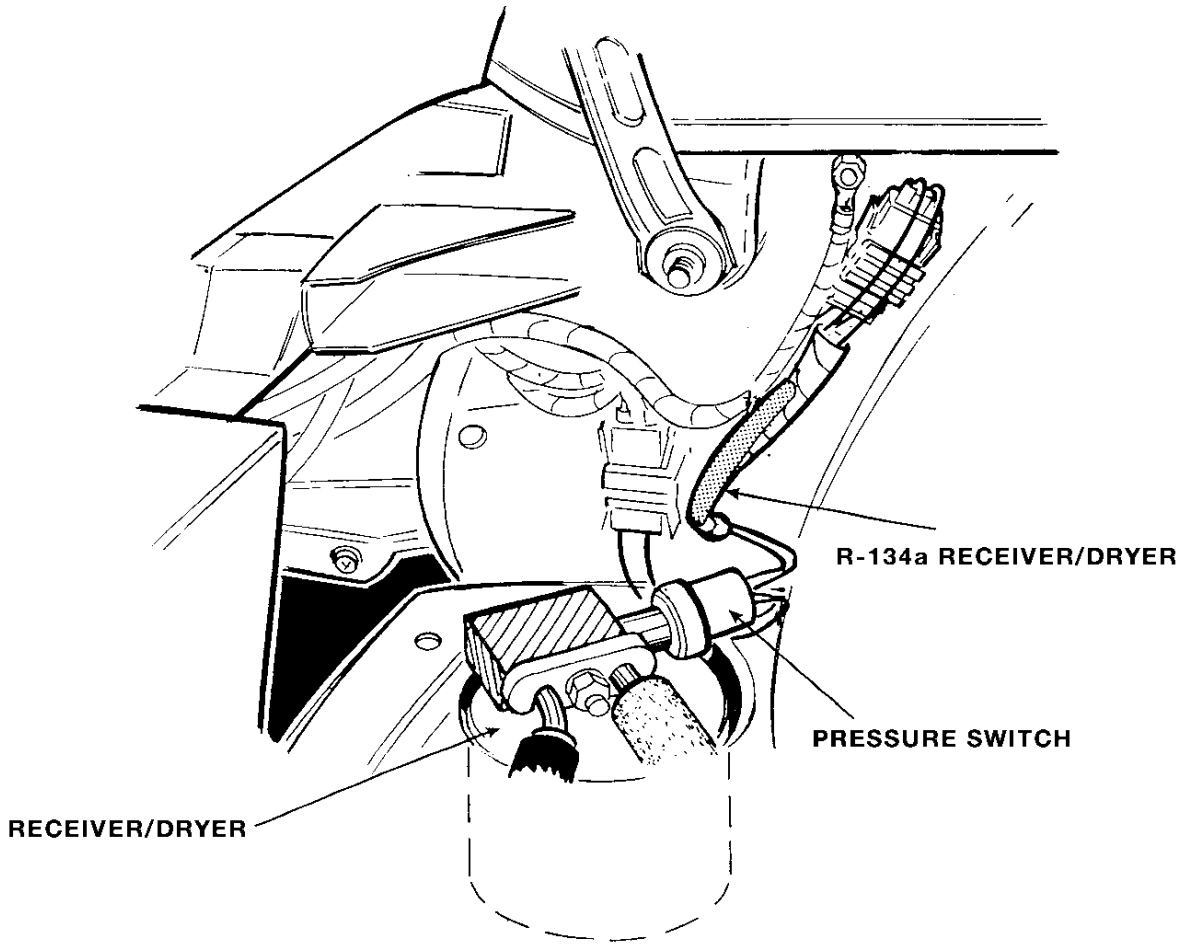


- A few bubbles show up intermittently, at intervals of 1 - 2 seconds.
- High-pressure side is warm and low-pressure side is fairly cold.
- Refrigerant likely to be insufficient.



R-134a RECEIVER/DRYER

The basic design of R-12 and R-134a receiver/dryers is the same. However, while R-12 systems typically use silica gel as a desiccant, R-134a systems use Zeolite. The drying capacity (per weight) of zeolite is only about 25% that of silica gel so R-134a receiver/dryers are larger, to accommodate larger amounts of desiccant. In addition, the high-pressure cutoff switch is rated higher for an R-134a receiver/dryer, since the system operates at higher pressures.



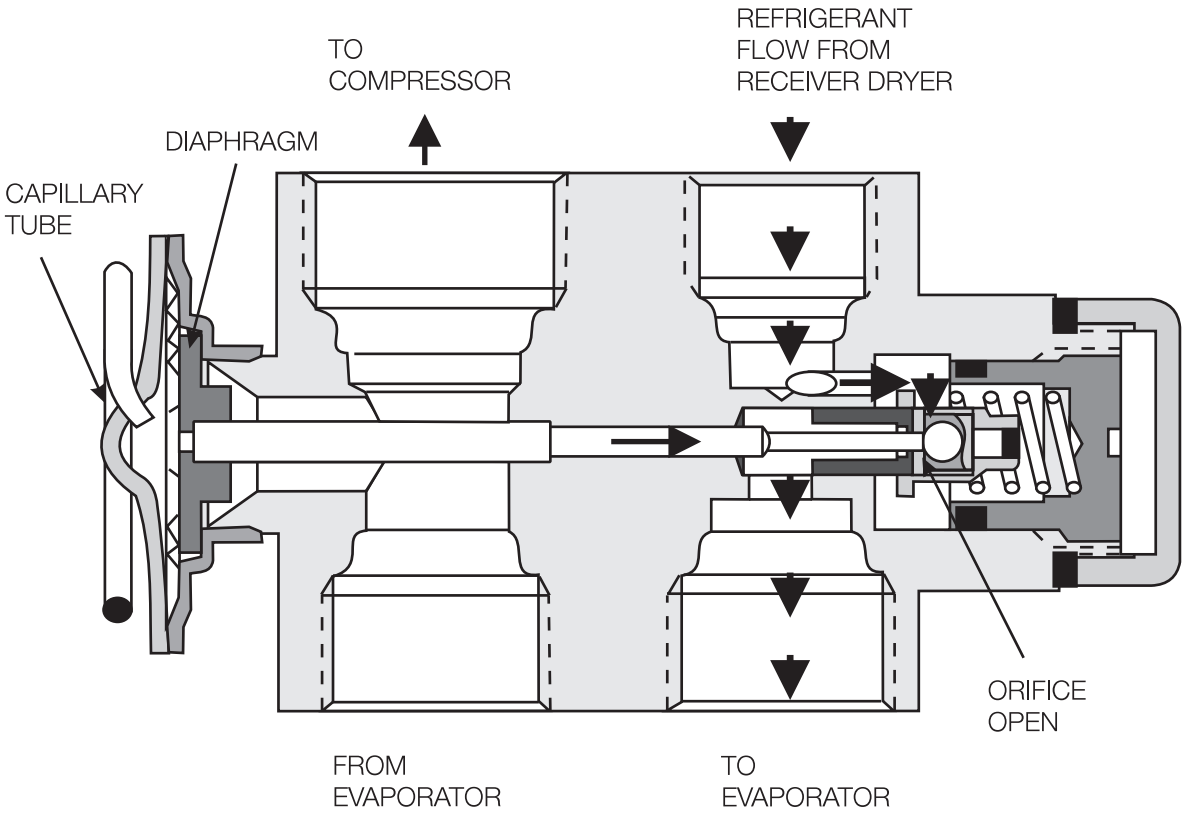
R-134a RECEIVER/DRYER

NOTES ON REPLACING DRYER FLASK

The dryer flask must be replaced when:

- there are contaminents in the refrigerant circuit (e.g. compressor has seized)
- the system is leaking and there is no more refrigerant in the system
- the refrigerant circuit was opened for longer than 24 hours during a repair.

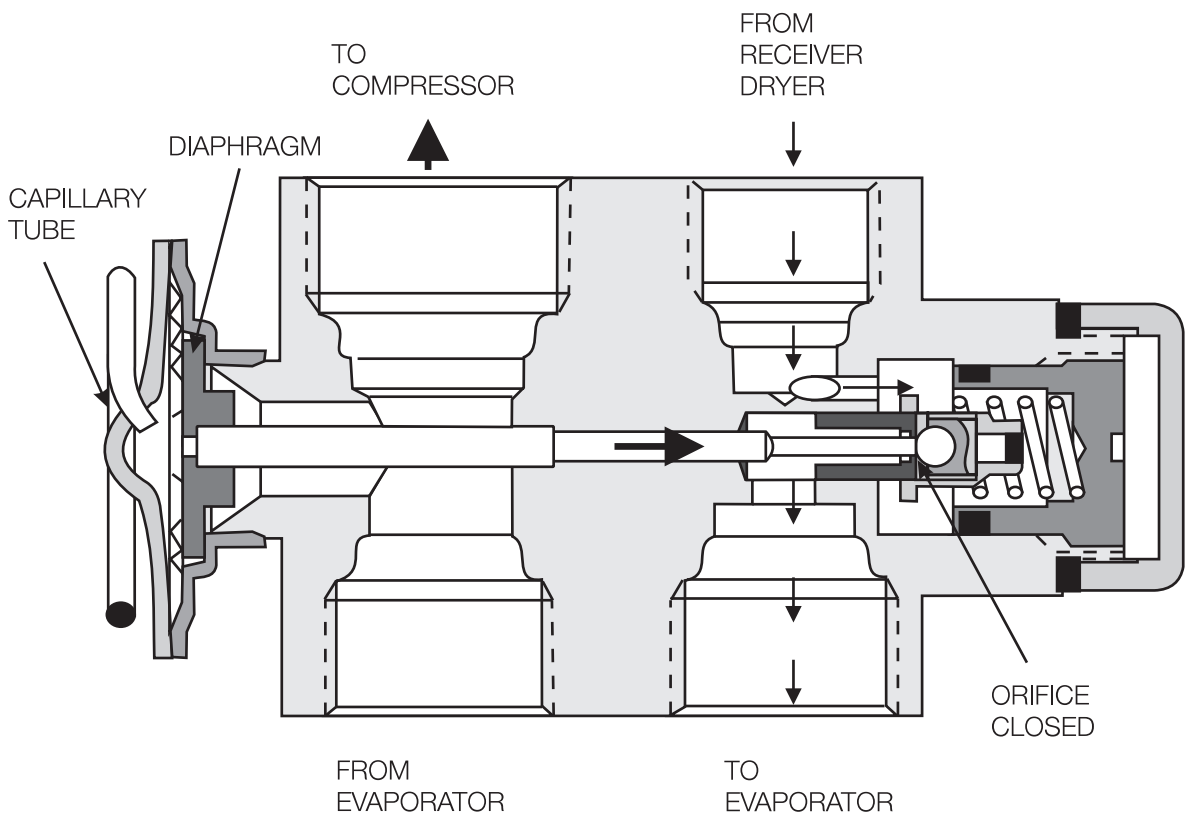
EXPANSION VALVE



The expansion valve controls the amount of refrigerant released into the evaporator. It is fitted to the evaporator inlet/outlet pipes. The valve separates the high-pressure side of the system from the low-pressure side. A small passage, or "orifice," allows only a small amount of liquid into the evaporator. The amount of refrigerant that it allows through depends on the evaporator temperature and pressure, and the temperature of the air passing through the evaporator.

If too little refrigerant enters the evaporator, poor cooling results. If too much refrigerant enters, it might not completely boil away and liquid refrigerant might return to the compressor, causing damage to the system.

A block-valve design of expansion valve is used on current BMW A/C systems. The refrigerant enters at the upper right inlet. At the left of the valve there is a capillary tube filled with an inert gas, that senses the temperature of the air coming into the housing from the plenum. When the air temperature in the plenum rises, the pressure in the capillary tube increases. This pushes down on a diaphragm and pushrod assembly, which increases the size of the orifice opening, allowing more refrigerant into the evaporator and providing more cooling. When plenum temperature falls, the pressure in the capillary tube falls. The spring pushes up on the pushrod, making the orifice opening smaller; less refrigerant is allowed into the evaporator, allowing less cooling.



Refrigerant from the outlet of the evaporator passes through the bottom left opening of the block valve. When the pressure at the evaporator outlet is high, this increases the pressure needed by the capillary tube, to open the valve. Less refrigerant is provided to the evaporator (to prevent the evaporator from being flooded). When pressure at the outlet end of the evaporator is lower, less pressure is exerted on the bottom of the diaphragm. The diaphragm pushes down on the pushrod, allowing more refrigerant into the evaporator.

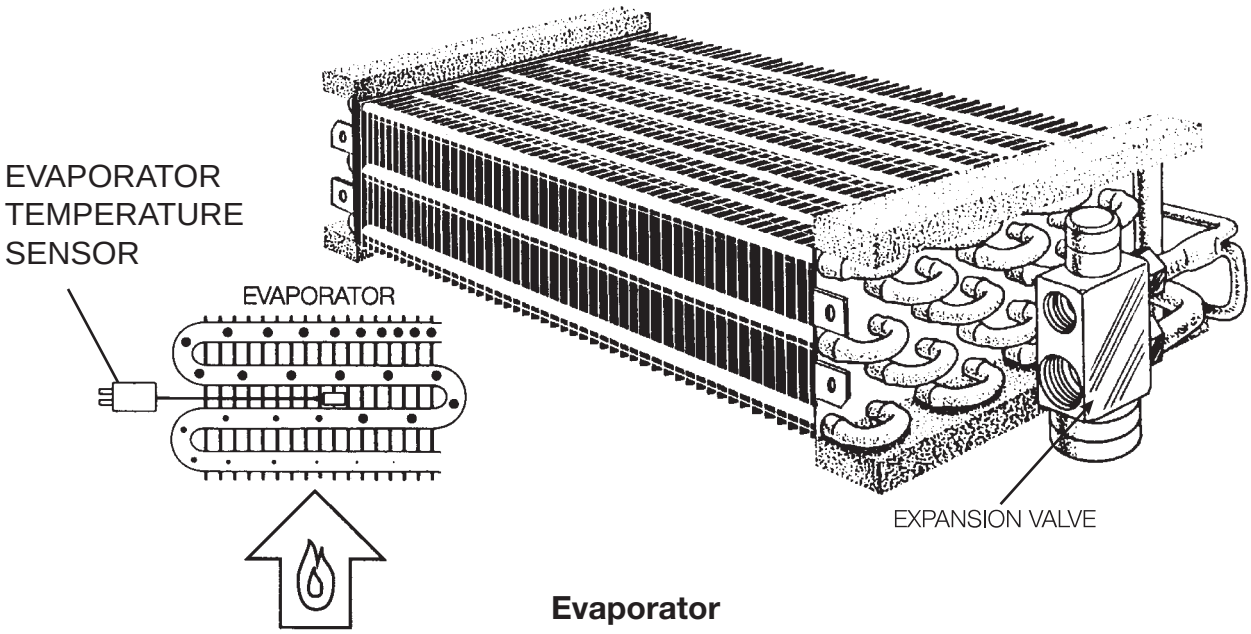
NOTE:

The R-134a system expansion valve uses a different operating pressure range. This enables the valve to work more efficiently with the new refrigerant. An expansion valve designed for use in an R-12 system, if installed in an R-134a system may not allow enough refrigerant into the evaporator. This may affect the performance.

If moisture gets into this system, it may freeze and clog the expansion valve. The A/C system may operate normally for a while, but then stop cooling. Then, as system temperature increases, the ice melts. The system works again for a while, until moisture freeze-up causes it to stop again. For diagnosis and correction of this problem, see page 17.

The expansion valve is unit replaceable; there are no adjustments or repairs.

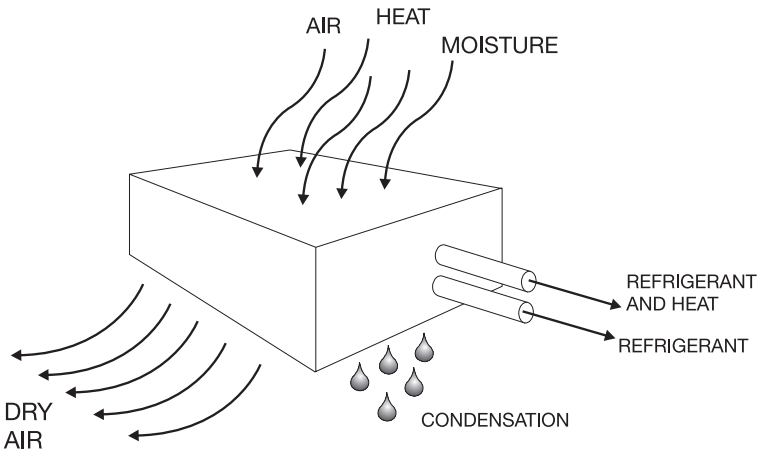
EVAPORATOR



Evaporator

From the expansion valve, the liquid refrigerant passes into the evaporator. Once the refrigerant passes the orifice in the expansion valve, its pressure drops. The liquid refrigerant, now in the evaporator, immediately begins to boil. As it boils, it absorbs heat from the air that passes over the fins and tubes of the evaporator. This cools the air and heats the refrigerant. The refrigerant, now a vapor again, is then drawn back into the low side of the system by the compressor.

The evaporator on current BMW cars is mounted crosswise in the housing. It is similar in construction to a radiator (a copper or aluminum coil with fins). The fins provide a large surface area to transfer heat from the air to the colder refrigerant inside the coil. The evaporator (like the condenser) is a "heat exchanger."

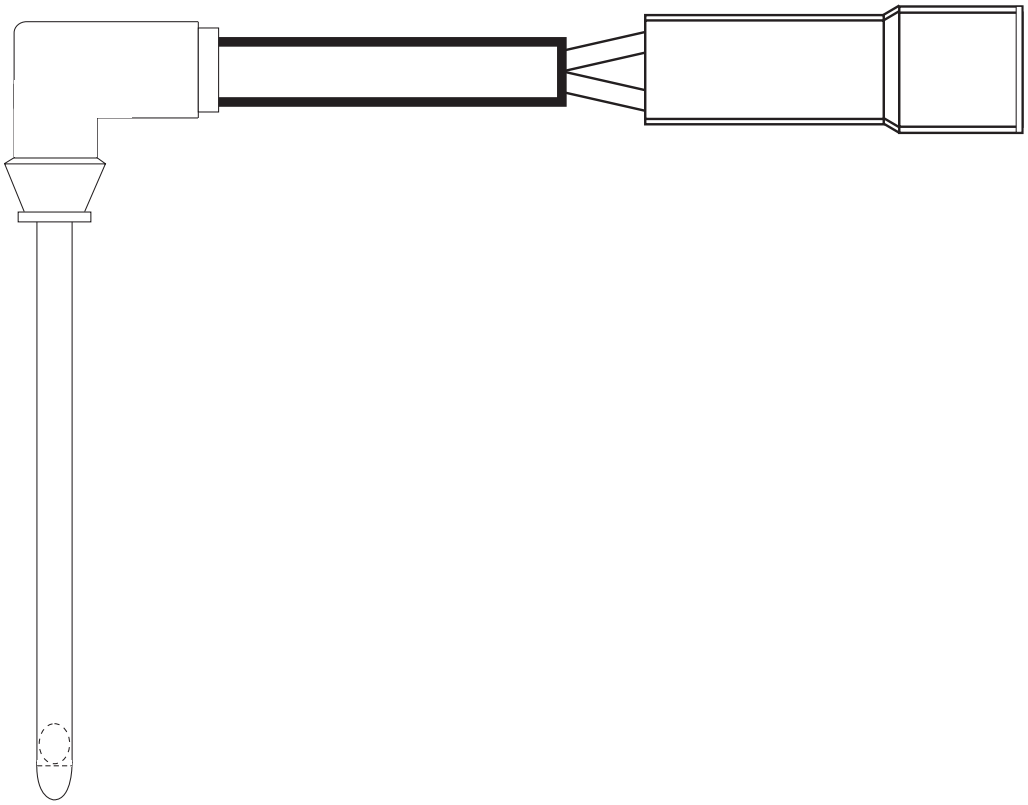


As air passes over the evaporator fins, the moisture condenses on the fins as the air cools. Water collects in the bottom part of the housing and exits through one or two drains.

Evaporator service:

- Check water drains.
- Straighten bent fins (a tool is available locally)
- A frost ring on a tube indicates a restriction. (On some vehicles, the evaporator and expansion valve can be accessed by removing the glove box.)

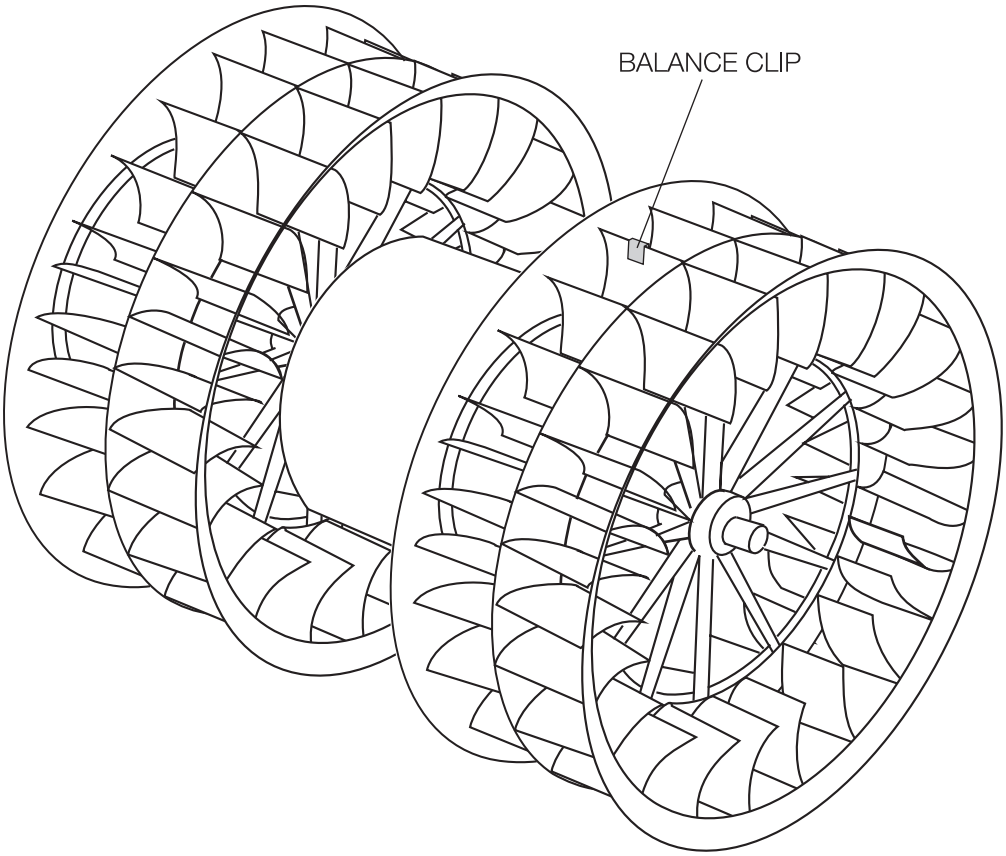
EVAPORATOR TEMPERATURE SENSOR



If the evaporator temperature is allowed to cool below 1° C, condensation can freeze on the evaporator. The ice then insulates it from the air passing over it, and it works much less efficiently. A temperature sensor is used to protect the evaporator from freezing, by signaling the control module to turn the compressor off, so that condensation cannot freeze on the evaporator. The compressor is typically disengaged at 34°-37ºF (1°-2º C). When the compressor is turned off, refrigerant flow is reduced and the evaporator temperature rises.

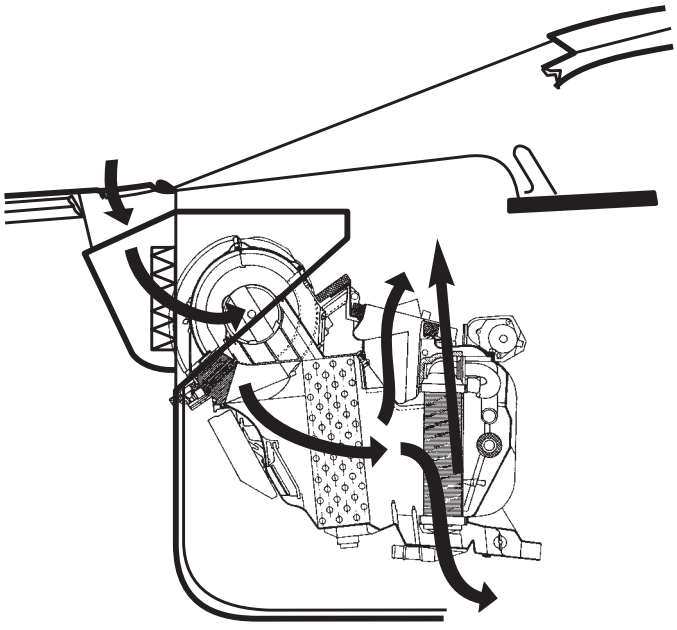
The temperature sensor is a Negative Temperature Coefficient (NTC) thermistor whose resistance varies according to the temperature of the evaporator core. Resistance is higher at lower temperatures, and decreases as the temperature rises.

BLOWER MOTOR



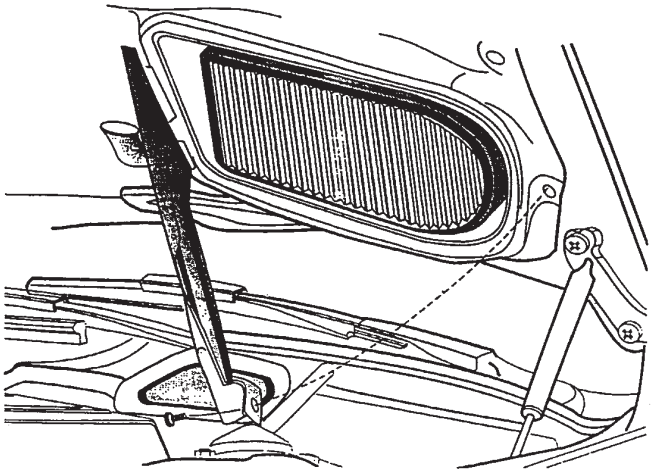
A dual squirrel-cage blower is used (on most BMWs) to propel air across the evaporator and/or the heater core and through the plenum to the vents. On BMW A/C systems, the blower speed is controlled by resistors/transistors that vary the amount of voltage applied to the blower, depending on the air volume control knob setting. In IHKA systems, the blower speed is controlled electronically.

Whenever the A/C is switched on, the fan runs at speed "1" or higher. Without the fan working, the evaporator could ice up, as humid air comes in contact with the fins.



MICROFILTERS

Microfilters are used in BMW climate control systems, this includes all vehicles produced after 9/91 (except E30). In addition, all E31 vehicles have been equipped with microfilters since start of production.



Shown in the above example is an E38 microfilter and location. Fresh air is continuously filtered through the microfilters. Never operate an E38 without the microfilters installed, there is the danger of water being drawn into the heater and/or damage to the electrical system.

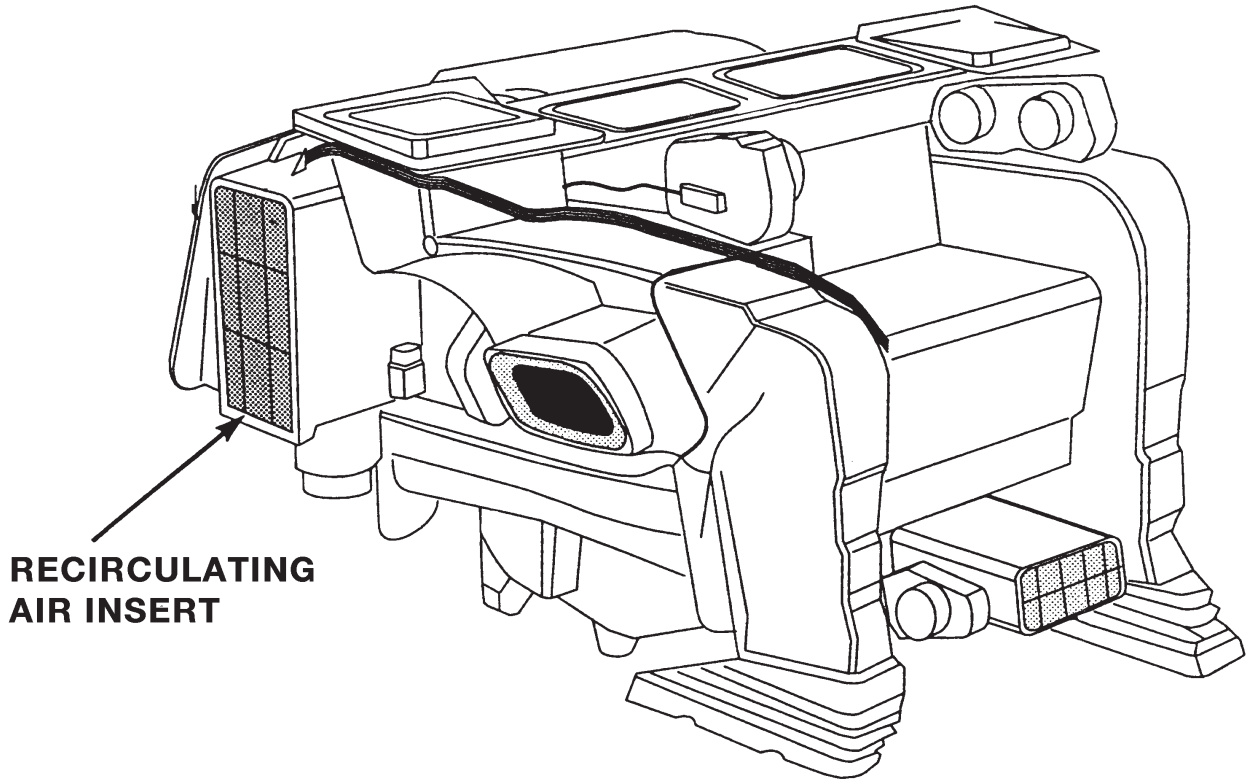
The microfilter is designed to trap potentially irritating types of particles with very high efficiency. Some examples include:

- Pollens
- Spores
- Dust
- Vapors
- Floating air pollution
- Bacteria
- Viruses

Under normal operating conditions the microfilter(s) should be replaced every Inspection I and II (also every Oil Service 99 MY), except for M roadster or M coupe. The actual service life of the microfilter depends on the amount of contaminant and air flow rate reduction complaint, therefore; the replacement interval may be more frequent in dusty operating conditions.

Refer to the repair manual for removal/installation procedure

E38 models have additional filters for the recirculation air inlets which require replacement at every second inspection II.



TYPES OF REFRIGERANTS

R-12

R-12 or Freon ®, was used in BMW air conditioning systems prior to 1992. It is a member of the class of compounds called “chlorofluorocarbons” (CFC’s).

Characteristics:

- Very durable.
- Transports heat very efficiently.
- Non-explosive when mixed with air.
- Odorless; not harmful to human health when handled correctly.
- Boils at -22° F (-30° C).
- Absorbs a large amount of heat when boiling.
- Does not react with most metals (except lead).
- Reacts with many synthetics.
- Reacts with water to produce acid.
- Mixes readily with mineral-based oil.

Skin should not be exposed to liquid R-12. Since R-12 boils at -22° F (-30° C), it can cause severe frostbite or freezing damage.

R-12 should never be exposed to an open flame. When it burns in air, it produces phosgene, a poisonous gas.

R-12 should be stored at room temperature, and not exposed to extreme heat.